# Article below:

Today's Headlines - July 20, 2000

A PULSE OF LIGHT BREAKS THE ULTIMATE SPEED OF LIGHT
from The Los Angeles Times

The textbooks all say the same thing: Nothing can move faster than light shooting through a vacuum. The textbooks, it seems, could be wrong.

A new experiment published in today's issue of the journal Nature has found an exception to the rule, showing that a pulse of light can apparently break the ultimate speed limit of 186,282 miles per second. A speeding light pulse can bend the laws of common sense--but not relativity--by exiting a chamber before it enters it, the experiment indicates.

If you're mystified, you're not alone. Even the lead physicist on the experiment, Lijun Wang of the NEC Research Institute in Princeton, N.J., said many of his colleagues are still puzzling about the true nature of light and over the new findings, which have been widely discussed among physicists. "There are lots of questions to be answered," he said.
<http://www.latimes.com/news/science/science/20000720/t000068166.html>

Visit the a home page for the experiment, dubbed Gain-Assisted Superluminal Light Propagation.
<http://www.neci.nj.nec.com/homepages/lwan/gas.htm>

**Chen, Shih-Chao**

**From:** Wimer, Mike
**Sent:** Friday, November 14, 2003 10:25 AM
**To:** Chen, Shih-Chao
**Subject:** FW: Gain-Assisted Superluminal Light Propagation

**David,**
**I'm unsure if this is relevant to your case, because the experiment below is for "light" and there is no discussion of "lower frequency" EM waves. But, I see no problem applying it there since it follows Maxwell's equations. (note: but for RF, the material must allow such phase relationship to occur).**
**Gain assisted superluminal light prop. is effected via a material called "an anomalous dispersion material."**
**See this link:**
**http://www.neci.nj.nec.com/homepages/lwan/gas.htm**
**Click on "Experiment" button.**
**In the "Table of Contents" box, click on: "a movie showing the pulse motion".**
**Click within the box "G.A.S. Animation".**
**(In IE, an .avi file is loaded automatically, and in Netscape, click on the graph to get it started moving).**
**You can read about how these waves interact and how it appears that faster than light is achieved in the red wave, here:**
**http://www.neci.nj.nec.com/homepages/lwan/sld004.htm**
**These links are on the contents page of the website.**
**As I said above, it may not be relevant, but maybe this is the explanation your applicant is using.**

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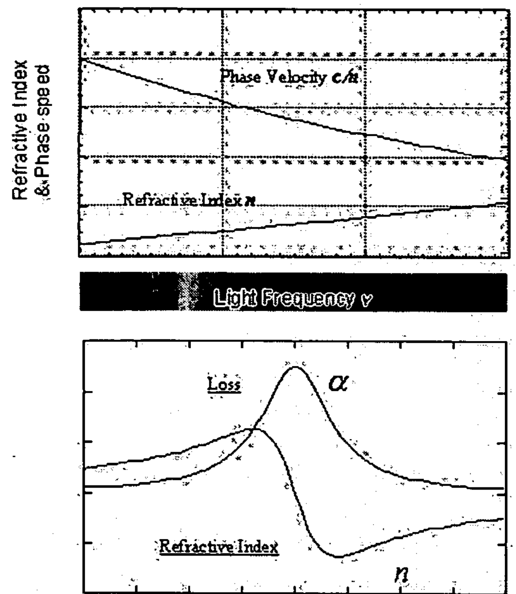
# Dispersion and Light Group Velocity

- ***Normal Dispersion (e.g. Glass).***
- **Phase velocity:** $V_p = \frac{c}{n}$
- ***Normal dispersion:*** $v \cdot \frac{dn}{dv} > 0$
- **Group index:** $n_g = n + v \cdot \frac{dn}{dv} > 1$
- **Group velocity:** $V_g = \frac{c}{n_g} < c$
- ***Anomalous Dispersion*** $v \cdot \frac{dn}{dv} < 0$

  $\Rightarrow n_g < 1, \Leftrightarrow V_g = c/n_g > c.$
- **Consequence: superluminal propagation.**
- ***Usually inside an opaque material (heavily absorbing).***



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# Gain-Assisted Anomalous Dispersion

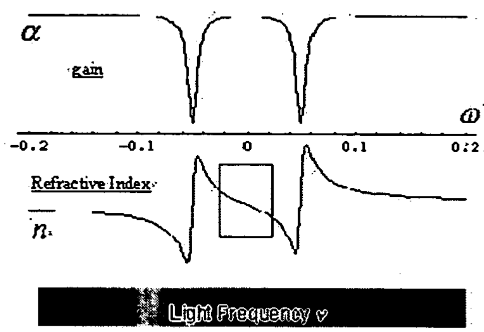
- ***Lossless Anomalous Dispersion between two closely-spaced gain lines:***

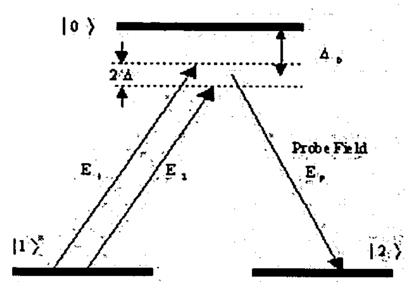
$$\boxed{\nu \cdot \frac{dn}{d\nu} < 0}$$

- **Group index:**

$$n_g = n + \nu \cdot \frac{dn}{d\nu} < 1 \text{ (even negative)}$$

- **Consequence: superluminal propagation of light pulses in a transparent material.**
- **Generation of two closely-spaced Raman gain peaks:**
- **(Atoms initially prepared in state $|1\rangle$ via optical pumping).**



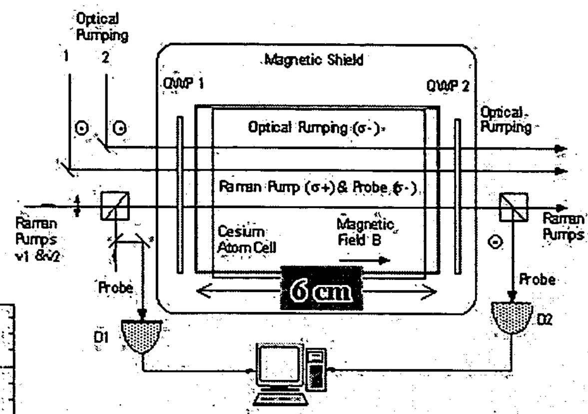



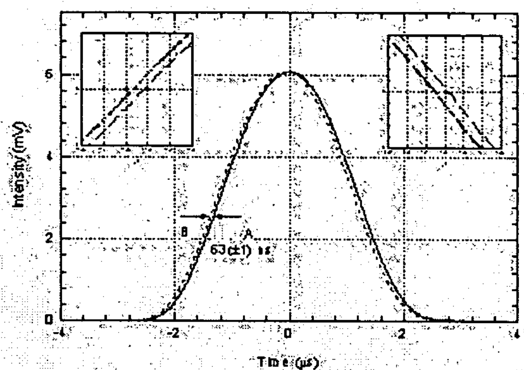
# Gain-Assisted Superluminality (GAS)

- ***Experimental Setup using Cesium Vapor***
- ***Observed Pulse Propagation:***

***Pulse advancement: 63 nanosecond***

***(~ 19 meters over a 6 cm Cesium Cell)***




$\Delta n = -1.8 \times 10^{-6}$; $\Delta \nu = 1.9$ MHz;

$\nu = 3.5 \times 10^{14}$ Hz;

$$n_g = n + \nu \frac{dn}{d\nu} = -330 \ (\pm 30)$$

## Schematic Illustration of "Re-phasing" and Superluminal Propagation

(Warning: the effect is greatly exaggerated for the purpose of illustration)

- A light pulse is made of many wave components of different wavelength (frequency). Here we show three of these components (wave 1 to 3). First in air, all three waves are in phase in region-1 where the waves add to produce a pulse. Slightly further in space along its propagation direction, the waves become "out of phase" and the waves cancel each other.
- In an anomalous dispersion region (Region-2 inside the Cesium atomic cell), a wave which has shorter wavelength in vacuum (wave-1) now has a longer wavelength. Conversely, a longer wavelength wave (wave-3) becomes a shorter wavelength wave.
- Hence the waves' phase are accordingly modified. When the three waves emerge again from the Cesium cell's exit surface, they restore their wavelengths. Due to the unusual phase modulation of the anomalous dispersion material, the three waves are in phase again in a third region (Region-3 in air). In this region, the three waves again add to produce the exact form of the incoming pulse.
- Ordinarily in air and as a matter of fact in all *normal dispersion* materials, a light pulse cannot re-phase to appear at a distant place along its propagation direction. Normally, the light pulse will appear at such a distant place along its propagation at a later time. However, owing to the extraordinary properties of an *anomalous dispersion* material, a light pulse can re-phase to appear at such a distant place along its propagation direction. Thus the light pulse behaves as if it takes a *negative* time to traverse the distance along its direction of travel.